1 **Adverse childhood experiences during childhood and academic attainment at age 7 and 11**

2 **years: an electronic birth cohort study**

3

4 **Abstract**

5 **Objectives**

6 Adverse childhood experiences (ACEs) have a negative impact on childhood health, but their impact

7 on education outcomes is less well-known. We investigated whether or not ACEs were associated

8 with reduced educational attainment at age 7 and 11 years.

9 **Study design**

10 Population based electronic cohort study

11 **Methods**

12 We analysed data from a total population electronic child cohort in Wales, UK. ACEs (exposures)

13 were living with an adult household member with any of (i) serious mental illness (SMI), (ii) common

14 mental disorder (CMD), (iii) an alcohol problem; (iv) child victimisation, (v) death of a household

15 member and (vi) low family income. We used multilevel logistic regression to model exposure to

16 these ACEs and not attaining the expected level at statutory education assessments, Key Stage (KS) 1

17 and KS2 separately, adjusted for known confounders including perinatal, socio-economic and school

18 factors.

19 **Results**

20 There were 107,479 and 43,648 children included in the analysis, with follow-up to 6-7 years (KS1)

21 and 10-11 years (KS2) respectively. An increased risk of not attaining the expected level at KS1 was

22 associated with living with adult household members with CMD (aOR 1.13 (95% CI 1.09-1.17) or an

23 alcohol problem (aOR 1.16 (95% CI 1.10-1.22), childhood victimisation (aOR 1.58 (95% CI 1.37-

24 1.82), death of a household member (aOR 1.14 95% CI 1.04-1.25) and low family income (aOR 1.92

25 95% CI 1.84-2.01). Similar results were observed for KS2. Children with multiple adversities had

26 substantially increased odds of not attaining the expected level at each educational assessment.

27 **Conclusion**

28 The educational potential of many children may not be achieved due to exposure to adversity in

29 childhood. Affected children who come in to contact with services should have relevant information

30 shared between health and care services, and schools to initiate and facilitate a coordinated approach

31 towards providing additional support and help for them to fulfil their educational potential, and

32 subsequent economic and social participation.

33

36

37

38

Introduction

Academic achievement during childhood is influenced by complex interactions between a range of biological, social and environmental factors including the home environment. Mental disorders and alcohol misuse are common in families. Although severe mental illnesses such as schizophrenia and bipolar disorder affect 1–2% of adults in the U.K.,[1,2] common mental disorders (CMD), including depression, anxiety, panic, and somatisation, can affect 16% of adults.[3] Alcohol misuse is also prevalent, affecting 8% - 10% of adults and a significant proportion also have co-occuring mental disorders.[4] We previously estimated that 30% of infants lived with an adult who had a mental disorder[5] and up to 30% of children have been reported to live with an adult binge drinker.[6]

Experience during childhood of long-term or acute stress for example due to mental disorders, alcohol related problems or a death in the household have been shown to increase the risk of unplanned hospital admissions during childhood, poorer mental and physical health (increased risk of cancer and cardiovascular disease), as well as negative social outcomes during adulthood (e.g. leaving school without qualifications, unemployment and incarceration).[7] The impact of these adverse experiences on education outcomes in school age children is less well-known.

Adverse childhood experiences are thought to elevate glucocorticoid hormones (cortisol), with chronic stress impeding the regulation of stress physiology. For example, children exposed to maternal depression have been shown to have higher levels of salivary cortisol, which could be a mediator in the pathway between chronic stress and lower executive functioning (e.g. working memory).[8] Differences in brain activity and hippocampal volume have also been observed according to whether or not children have experienced maltreatment or neglect, but the reasons for this are unclear.[9,10] The pre-frontal cortex and executive functions of the brain are known to be sensitive to stress,[11] therefore we hypothesised that exposure to adverse childhood experinces impacts negatively on educational attainment during childhood, and contributes to the observed inequalities in education outcomes in children. Understanding the contribution of childhood adversity that may be preventable to the observed social inequalities in education outcomes is important to help us undertand the potential impact that interventions that build resilience and mitigate the effects of early adversity can have on on later health, wellbeing, economic activity and social participation.

In this study we investigated whether or not adverse childhood experiences were associated with reduced educational attainment at age 7 and 11 years, and the magnitude of these effects, whilst taking in to account the effects of area level social deprivation, school factors, household composition, socio-demographic and perinatal health indicators using linked administrative datasets. We also

74 explored whether or not children who experienced adversity were more likely to have special

75 education needs requiring learning support.

76 **Methods**

77

78 **Data sources and study design**

79

80 The Wales Electronic Cohort for Children (WECC), has records for 981 404 children born between

81 1990 and 2012, for a child or mother resident in Wales[12] with information held in the Wales

82 Demographic Service Dataset (a Wales-wide administrative register for all individuals with a general

83 practitioner (GP)). WECC is derived by record-linking de-identified routinely collected health and

84 social datasets described in Table 1, using a unique Anonymised Linking Field (ALF) for each

85 individual. It is accessed through the Secure Anonymised Information Linkage (SAIL) databank at

86 Swansea University, UK.[13,14] To enable individuals living in the same household to be anonymously

87 linked, residential anonymised linking fields (RALFs) were created by encrypting individual's

88 addresses for the study period.[15,16]

89
90 **Table 1: Data sources**

Datasets*	Data source**
Wales Electronic Cohort for Children	Wales Demographic Service Office of National Statistics birth records Office of National Statistics death records National Community and Child Health database Congenital Anomaly Register and Information Service
Hospital inpatient admission data	Patient Episode Dataset for Wales
General Practice data	General Practice Database
Education data	Pupil Annual School Census National Pupil Database
*Datasets were linked for each child's record using an anonymised linking field based on their NHS number produced by the NHS Wales Informatics Service (NWIS), a NHS trusted third party, with more than 99.85% accuracy.[14] ** data sources are described in supplementary Table 1.	

91
92
93 We included children who had data available for statutory educational assessments in the UK at age

94 6-7 years and 10-11 years, and for whom adult household members had sufficient GP data to ascertain

95 exposure measures. Exclusions are described in figure 1. To preserve the temporal order of exposure

96 and outcomes in the analyses, only those children who took the statutory assessment at the expected

97 age (using proxy start date of 1st May for each year) were included in the analyses.

98

99 The Wales Electronic Cohort for Children was approved by an independent Information Governance

100 Review Panel. The Wales Electronic Cohort for Children was judged by the Research Ethics

101 Committee for Wales to be an anonymised research database that does not require ethical review, in

102 line with National Ethics Committee guidance.

103

Outcomes

Children in Wales have two statutory assessments during compulsory education that is normally taught between ages 5-7 years and 8-11 years[17] (two further assessments are taken at age 13-14 and age 15-16 years). In this analysis, the education outcomes were attaining the expected level in statutory assessment at (i) age 6-7 years, Key Stage 1 (KS1) and (ii) age 10-11 years, Key Stage 2 (KS2). KS1 and KS2 are teacher assessments (rather than formal tests) in three core subjects (a language, mathematics and science) where an overall binary measure is derived to indicate whether the expected standard is met or not.

A third outcome about provision of extra learning support for a child at school (Special Educational Need (SEN) provision) was also investigated as an indicator of impaired academic performance. This was coded as a yes/no binary variable, indicating any help received by a child, which may include one to one help or support through external provision to the school (described in UK local educational authority schools as School action, School action plus and Statemented).

Exposures

Exposure was measured (i) between birth to age 6-7 years (KS1) and (ii) between birth to age 10-11 years (KS2). Household members were defined as those living in the same household as the child on their 1st, 5th and 8th birthday.

We defined six measures of childhood adversity. Three of these related to living with an adult household member with any of: (i) serious mental illness diagnosis (e.g. bipolar disorder, schizophrenia);[18] (ii) CMD (e.g. depression, anxiety)[19] and (iii) an alcohol problem defined by a record of heavy drinking in primary care records[20] or an alcohol-related hospital admission[21], dating back to 1998. The fourth measure was childhood victimisation defined as an inpatient hospital admission of the child where victimisation was a contributing reason for admission[22]. The fifth measure was death of a household member and the sixth measure was low family income, defined as eligibility for free school meals in the year the Key Stage assessment was taken.

We used validated algorithms for ascertaining cases of CMD using diagnosis, symptoms and treatments[19] and lifetime diagnosis of psychotic disorders[18] recorded in GP datasets. Problematic alcohol use among household members was ascertained using a set of General Practice symptoms, diagnosis and procedures (Read Version 2) codes that we had previously defined[20] for current or past heavy alcohol drinking (anything above the recommended limit), alcoholic disease (liver or other), poisoning or treatment evidence and/or any alcohol-related emergency hospital admission during the exposure period. Childhood victimisation was ascertained using a defined set of ICD-10 codes in any position of the first consultant episode of an inpatient hospital admission[22]. For adult household

141   members living with the child at age 1 year, we separated out the presence of alcohol-related

142   problems, CMD or serious mental illness according to whether they were recorded before the birth of

143   the child (pre-birth) or during the first year of life.

144

145   **Statistical analysis**

146

147   We used multilevel logistic regression to model exposure to adverse childhood experiences and (i) not

148   attaining the expected level at KS1and KS2 separately and (ii) receipt of special educational need

149   provision. Multilevel modelling was used to include the hierarchical structure of children within

150   schools, so that correlation attributable to schools could be included in the modelling. For each

151   exposure, we estimated odds ratios (ORs) with 95% confidence intervals (CI), adjusting for

152   confounding variables. We used likelihood ratios to test two-way interaction terms between

153   exposures, and between each exposure and each of maternal age, single adult household, and small-

154   area deprivation. We repeated the analyses to estimate ORs for any SEN provision allocated in the

155   year the Key Stage assessment was taken, adjusted for maternal and perinatal characteristics.

156

157   A Direct Acyclic Graph (DAG)[23] was drawn to visualise confounding relationships and obtain a

158   minimal sufficient adjustment set of potential confounders for analyses (figure 2 & 3). We adjusted

159   for household composition (living in a single adult household) and measures of social disadvantage

160   including young maternal age (<18 years) and small-area deprivation (based on Townsend score,[24]

161   using the 2001 census for income and address). Perinatal factors (such as gestational age, academic

162   season of birth, and breastfeeding at birth or 6–8 weeks [when the NHS collects such data]) were

163   adjusted for as the DAG confirmed these factors were on the causal pathway but were not mediators

164   between adverse childhood experiences and educational attainment. We also adjusted for school

165   factors (number of school moves, average size of school and percentage of children eligible for free

166   school meals) at each Key Stage assessment.

167

168   Data were missing for breastfeeding (22% and 42%) and maternal smoking (70% and 80%) in the

169   KS1 and KS2 cohorts respectively. The slightly higher proportions in the KS2 cohort were due to

170   lower data completeness in the earlier years of the cohort. Tabulations by year and unitary authority

171   showed that these could be reasonably assumed to be missing at random, due to organisational and

172   administrative differences in data collection between hospitals. There was little difference between

173   statistical model imputations for these variables so we concluded that the cohorts were large enough

174   to give sufficient precision. All other variables had less than 5% missing data. Multiple imputation

175   with chained equations[25] was used to account for missing data with all covariates and the outcome

176   variable included in the imputation model as described by White and Royston.[26] The results of the

177 multilevel modelling were consistent for complete case and the imputed dataset, so we present results

178 from the multiply imputed datasets. We used Stata IC (version 13) for statistical analyses.

179

180 **Role of the funding source**

181

186

187 **Results**

188 There were 107,479 and 43,648 children in the cohort between 1998 and 2012 who were included in

189 this analysis, with follow-up to 6-7 years (KS1) and 10-11 years (KS2) respectively (figure 1).

190 Sociodemographic characteristics of the children were representative of national population statistics

191 in both cohorts (Supplementary table 2). About 3% of children (n=3,313) were born to a mother who

192 was under 18 years of age at childbirth, and 35,651 (33.2%) had lived in a single adult household (16+

193 years of age) between birth and age 6-7 years.

194

195 Overall 19,508 (18.2%) of children did not attain the expected levels at KS1, 8462 (19.4%) did not

196 attain the expected level at KS2, 27,393 (25.5%) and 11,910 (27.3%) had some SEN provision in the

197 year they took KS1 and 2 (Table 1).

198

199 15,553 (14.5%) children aged 1 year lived with an adult who had a history of CMD, and 41,257

200 (38.4%) children lived with an adult who had a CMD between birth and age 6-7 years (Table 1). Less

201 than 1% of children had lived with an adult who had a serious mental illness. Children who lived with

202 adult household members with common mental disorder had an increased odds of not attaining both

203 KS1 (aOR 1.13 (95% CI 1.09-1.17) and KS2 aOR 1.13 (95%CI 1.07-1.19). A record of serious

204 mental illness in a household adult between birth and KS1 was also associated with increased odds of

205 not attaining KS1 (aOR 1.21 (95% CI 1.02-1.42) but not at KS2 (aOR 0.97 (95% CI 0.79-1.19)). The

206 magnitude of effect for these two exposures at KS1 are similar because the majority of children in this

207 cohort (67.6%) who lived with an adult who had a serious mental illness were also exposed to CMD

208 in the household (Table 2).

209

210 Eleven percent of children in the KS1 cohort (n=12,224) and 17.1% (n=7,480) in the KS2 cohort had

211 lived with an adult with an alcohol related problem; these children had an increased odds for not

212 attaining KS1 (aOR 1.16 (95% CI 1.10-1.22) and KS2 (aOR 1.16 (95% CI 1.09-1.24)), after adjusting

213 for perinatal, socio-demographic, other adverse experiences and school factors.

214

215 One percent of children were admitted to hospital during the study period with recorded victimisation,

216 and this group were also less likely to attain KS1 (aOR 1.58 (95% CI 1.37-1.82) and KS2 (aOR 1.88

217 (95% CI 1.52-2.33)) and more likely to have received SEN provision at KS1 (aOR 1.90 (95% CI

218 1.66-2.17) and at KS2 (aOR 1.79 (95% CI 1.46-2.20).

219

220 About three percent of children in the cohort experienced the death of a household member and this

221 was associated with an increased odds of not attaining KS1 (aOR 1.14 95% CI 1.04-1.25) and KS2

222 (aOR 1.13 95% CI 1.03-1.25). Low family income (measured as eligibility for a free school meal in

223 the year of taking KS1 or KS2) was also associated with an increased odds of not attaining KS1 (aOR

224 1.92 95% CI 1.84-2.01) and KS2 (aOR 1.65 95% CI 1.53-1.78).

225

226 The effects of socio-economic deprivation were similar on attainment at KS1 and 2, with lower levels

227 of attainment associated with higher levels of social deprivation. Young maternal age and percentage

228 of free school meals in the school attended in the Key Stage year, were both associated with lower

229 educational attainment, although the magnitude of these associations were slightly smaller at KS2

230 compared with KS1. Children born to older mothers 30+ years were more likely to receive SEN

231 provision at KS1, while children born to younger mothers (under 24 years) were more likely to

232 receive this at KS2.

233

234 The inclusion of the two-way interaction terms between exposures, and between exposures and each

235 of maternal age, single adult household, and small-area deprivation did not improve the fit of the

236 model to the data at the 5% level. Where present, interactions failed to show consistent,

237 monotonically increasing or decreasing patterns of adjustment to the main effects of interest.

238 Moreover, they did not alter any of our substantive findings, consisting of changes to the third or

239 fourth decimal place. Consequently, interactions were excluded in subsequent modelling and

240 interpretation.

241

242 Children who had multiple adversities had substantially increased odds of not attaining the expected

243 level at each educational assessment as shown in figure 4, signalling a clear need for early

244 intervention in this group intervention to mitigate . For example the odds of not attaining KS1 are

245 3.59 times higher (aOR 3.59 95%CI 3.25-3.96) for a child who lives in a household in an area with

246 the highest level of social deprivation, is eligible for free school meals, and lives with an adult who

247 has a common mental disorder and alcohol related problems, compared with a similar child who lives

248 in a household in an area with the lowest level of social deprivation (Table 4). These data signal a

249 clear need for early identification of this group and intervention to mitigate the impacts of multiple

250 childhood adversities on education and subsequent longer-term social and economic outcomes.

251

Discussion

253

254 This study shows that children exposed to adverse experiences during childhood were less likely,
255 compared to non-exposed peers, to attain the expected level of education at age 6-7 years (KS1) and
256 age 10-11 years (KS2) after controlling for socio-demographic characteristics, perinatal health
257 indicators, household composition and school factors. The magnitude of this association varied
258 according to the type and timing of exposure. For example, exposure during the first year of life to
259 adults who had a history of CMD had a lower magnitude of effect on KS attainment compared to
260 exposure during the years leading up to taking the KS assessments. The observed effect sizes for
261 exposure to mental disorder or alcohol problems in the household were in addition to those observed
262 for living in areas with high levels of social deprivation, suggesting that reducing the prevalence of
263 these household exposures as well as ensuring children who are exposed are identified early and
264 supported appropriately could make a difference to educational outcomes. The effects of these
265 exposures were cumulative, such that children who had multiple exposures had an even higher
266 likelihood of not attaining the expected level at KS assessments. Childhood victimisation and low
267 family income had the biggest effect sizes for not attaining the Key Stages, possibly reflecting the
268 severity of these exposures. Our measure of victimisation was based on hospital admissions only and
269 is therefore likely to underestimate the true impact of victimisation on education outcomes. These
270 findings highlight the importance trauma informed services for early detection of and intervention for
271 affected children, including the need for additional support to mitigate the future impact on
272 educational outcomes. Death of a household member was also associated with an increased risk of not
273 attaining the expected level at KS assessments. We did not have sufficient data to explore this effect
274 according to the relationship between the child and household member who had died or age at which
275 this occurred. Further work is needed to fully understand how and in what circumstances death in a
276 household impacts on a child's health and wellbeing.

277

278 Only one previous study has investigated the impact of multiple adverse expeiences during childhood
279 on educational outcome.[27] This Australian study reported that alcohol use, mental health issues and
280 death of a parent increased the risk of poorer reading attainment at age 8 years but their analyses did
281 not take account of differences in school factors, or examine the cumulative effects of child adversity
282 on educational outcome. Other studies have included wider age ranges of children between 5 to 17
283 years, reported detrimental effects on educational attainment for household alcohol misuse,[27-30] mental
284 health[31], or death in the household,[32-34] and victimisation of the child.[35-37] Most of these studies
285 examined the impact of single adverse exposures and none adjusted for the multiple confounders of

286 deprivation, birth and socio-demographic characteristics, and school factors including school

287 concentration of poverty as we have done in our analysis.

288 We have previously shown that some adverse childhood experiences are socio-economcally patterned

289 and that these rarely occur in isolation.[5,7] Our study therefore adds to the current body of evidence by

290 considering the collective impact of a range of adverse exposures in the household, in addition to

291 socio-economic indicators on educational outcomes.

292 The key strength of this study is that it measures adverse exposures in the household using

293 administrative and healthcare data. This addresses the limitation of some previous studies which have

294 relied on self-reported data to ascertain exposure during childhood. It also uses data on a wide range

295 of perinatal, socio-demographic and school level data, to take account of the complex relationships

296 between these variables and the association between adverse childhood experiences and educational

297 outcomes. One limitation is the reliance on coding of administrative data and potential for

298 misspecification of coding, however any misclassification is unlikely to disproportionately affect one

299 group over another and so is unlikely to have created a bias in any particular direction. We did not

300 have data on parental education or IQ (as a proxy for variation in school engagement) nor on contact

301 with social care and therefore could not explore the role of these variables. Our data showed that 27%

302 of children had SEN provision however we were unable to explore any unmet need or the

303 appropriateness of this provision for individual children.

304

305 At a population level, our study demonstrates how the educational potential of many children may not

306 be achieved due to exposure to adversity in childhood. Although the distribution of adverse childhood

307 experiences are socially patterned, our results suggest that the impacts of ACEs on educational

308 outcomes are in addition to those related to social deprivation. Thus, a combination of poverty and

309 childhood exposure to household mental disorders and alcohol related problems increases the

310 likelihood of failing the basic educational tests in language and maths by over 350% for children

311 living in the most compared to least deprived areas.

312 Critically, a poor start in education has been strongly linked with poorer educational outcomes across

313 all schooling years, poorer employment prospects and consequently a poor economic outlook across

314 the life course.[7,38-40] Consequently, exposure to ACEs increases the chances that children develop into

315 adults with poor economic prospects; contributing to a cycle of hardship that fuels inequalities and

316 potentially locks families into deprivation and ill health across generations. There are already a range

317 of evidence-based interventions that provide parent and care-giver support,[41,42] pre-school

318 enrichment[43,44] and increasingly, trauma-informed educational services.[45,46] It is no longer a lack of

319 effective interventions or sound economic arguments that is preventing safe and secure childhoods. It

320 is only a question of the political investment necessary to ensure subsequent generations achieve their

321 full potential for themselves and for the prosperity of communities in which they live.

322

In conclusion our study shows that children living with adults who have mental disorders or alcohol problems, who have experienced victimisation or experienced a death in the family are at increased risk of not achieving their educational potential. As these experiences are relatively common, it is important that appropriate conversations are initiated when affected children come in to contact with health and care services, and that relevant information is shared between health and care services and schools to facilitate a coordinated approach to tackle adverse household exposures such as alcohol misuse and family violence as early as possible, whilst supporting affected families and children. It is also important that schools are adequately resourced to provide the additional support needed for children from affected families to reduce their risk of lower educational outcomes and help them to fulfil their educational potential, and subsequent economic and social participation.

Author statement

References

1. Saha S, Chant D, Welham J, McGrath J. A systematic review of the prevalence of schizophrenia. *PLoS Med* 2005; **2:**413–33.

2. Smith DJ, Nicholl BI, Cullen B, Martin D, Ul-Haq Z, Evans J et al. Prevalence and characteristics of probable major depression and bipolar disorder within UK Biobank:cross-sectional study of 172,751 participants. *PLoS One* 2013; **8:**e75362.

3. McManus S, Bebbington P, Jenkins R, Brugha T. Mental health and wellbeing in England: Adult Psychiatric Morbidity Survey 2014. Leeds: NHS Digital, 2016.

4. Drummond C, McBride O, Fear N, Fuller E. Chapter 10: alcohol dependence. In: Mental Health and Wellbeing in England: Adult Psychiatric Morbidity Survey 2014. Leeds: NHS Digital, 2016.

5. Paranjothy S, Evans A, Bandyopadhyay A, Fone D, Schofield B, John A et al. Risk of emergency hospital admission in children associated with mental disorders and alcohol misuse in the household: an electronic birth cohort study. *The Lancet Public Health 2018*; **3**(6):Pe279-e288.

6. Manning V, Best DW, Faulkner N, Titherington E. New estimates of the number of children living with substance misusing parents: results from UK national household surveys. *BMC Public Health* 2009; **9**:377.

7. Hardcastle K, Bellis MA, Ford K, Hughes K, Garner J, Rodriguez GR. Measuring the relationships between adverse childhood experiences and educational and employment success in England and Wales: findings from a retrospective study. *Public Health* 2018; **165**:106-116.

8. Finegood ED, Wyman C, O'Connor TG, Blair CB, The Family Life Project. Investigators Salivary cortisol and cognitive development in infants from low-income communities. *Stress* 2017; **20**(1):112–121.

9. Schiffer F, Teicher M, Papanicolaou A. Evoked potential evidence for right brain activity during the recall of traumatic memories. *J Neuropsychiatry Clin Neurosci* 1995; **7**:169–175.

10. Teicher M, Dumont N, Ito Y, Vaituzis C, Giedd J, Andersen S. Childhood neglect is associated with reduced corpus callosum area. *Biol Psychiatry* 2004; **56**:80–85.

11. Shields GS, Sazma MA, Yonelinas AP. The Effects of Acute Stress on Core Executive Functions: A Meta-Analysis and Comparison with Cortisol. *Neurosci Biobehav Rev.* 2016 ; **68**:651–668.

12. Hyatt M, Rodgers S, Paranjothy S, Fone D, Lyons R. The Wales electronic cohort for children (WECC) study. *Arch Dis Child Fetal and Neonatal Ed* 2011; **96**(suppl 1):Fa18.

13. Ford DV, Jones KH, Verplancke JP, Lyons RA, John G, Brown G, Brooks CJ et al. SAIL Databank: building a national architecture for e-health research and evaluation. *BMC Health Serv Res* 2009; **9**:157.

14. Lyons RA, Jones KH, John G, Brooks CJ, Verplancke JP, Ford DV et al. The SAIL databank: linking multiple health and social care datasets. *BMC Med Inform Decis Mak* 2009; **9:**3.

15. Rodgers SE, Demmler JC, Dsilva R, Lyons RA. Protecting health data privacy while using residence-based environment and demographic data. *Health Place* 2012; **18**:209–17.

16. Rodgers SE, Lyons RA, Dsilva R, Jones KH, Brooks CJ, Ford DV et al. Residential Anonymous Linking Fields (RALFs): a novel information infrastructure to study the interaction between the environment and individuals' health. *J Public Health* 2009; **31**:582–88.

17. National Foundation for Education Research (NFER) Statutory assessment in compulsory education in Wales: summary tables. Available: http://www.nfer.ac.uk/nfer/index.cfm?AE4CDC07-C29E-AD4D-0B50-575F25B37AA9. [accessed 2/7/2013].

18. Economou A, Grey M, McGregor J, Craddock N, Lyons RA, Owen MJ et al. The health informatics cohort enhancement project (HICE): using routinely collected primary care data to identify people with a lifetime diagnosis of psychotic disorder. *BMC Res Notes* 2012; **5**:95.

19. John A, McGregor J, Fone D, Dunstan F, Cornish R, Lyons RA et al. Case-finding for common mental disorders of anxiety and depression in primary care: an external validation of routinely collected data. *BMC Med Inform Decis Mak* 2016; **16**:35.

20. Trefan L, Akbari A, Paranjothy S, Farewell DM, Gartner A, Fone D, Greene GJ et al. Electronic Longitudinal Alcohol Study in Communities (ELAStiC) Wales – protocol for platform development. *International Journal of Population Data Science* 2019; **4**(1):14.

21. Fone DL, Morgan J, Fry R, Rodgers S, Orford S, Farewell D et al. Change in alcohol outlet density and alcohol-related harm to population health (CHALICE): a comprehensive record-linked database study in Wales. *Public Health Res* 2016; **4**:3.

22. Lee JJ, Gonzalez-Izquierod A, Gilbert R. Risk of Maltreatment-Related Injury: A Cross-Sectional Study of Children under Five Years Old Admitted to Hospital with a Head or Neck Injury or Fracture. *PLoS One* 2012; **7**(10):e46522.

23. Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. *Epidemiology* 1999; **10**:37–48.

24. Townsend P. Health and deprivation: inequality and the north. London: Routledge, 1989.

25. White IR, Royston P, Wood AM. Multiple imputation using chained equations: issues and guidance for practice. *Stat Med* 2011; **30**:377. e46522–99.

26. White IR, Royston P. Imputing missing covariate values for the Cox model. *Stat Med* 2009; **28**:1982–98.

27. Maclean MJ, Taylor CL, O'Donnell M. Pre-existing adversity, level of child protection involvement, and school attendance predict educational outcomes in a longitudinal study. *Child Abuse and Neglect* 2016; **51**:120-131.

28. Geoffroy M, Pereira SP, Li L, Power C. Child neglect and maltreatment and childhood-to-adulthood cognition and mental health in a prospective birth cohort. *Journal of the American academy of child & adolescent psychiatry* 2016; **55**(1).

29. Scarborough AA, McCrae JS. School-age special education outcomes of infants and toddlers investigated for maltreatment. *Children and youth services review* 2010; **32**:80-88.

30. Fletcher J, Vidal-Fernandez M, Wolfe B. Dynamic and heterogeneous effects of sibling death on children's outcomes. *PNAS* 2018; **115**(1):115-120.

31. Le HT, Nguyen HT. Parental health and children's cognitive and noncognitive development: New evidence from the longitudinal survey of Australian children. *Health Economics* 2017; **26**:767-1788.

32. Berg L, Rostila M, Saarela J, Hjern A. Parental death during childhood and subsequent school performance. *Pediatrics* 2014*;* **133**(4).

33. Bethell CD, Newacheck P, Hawes E, Halfon N. Adverse childhood experiences: assessing the impact on health and school engagement and the mitigating role of resilience. *Health affairs* 2014; **33**(12): 2106-2115.

432 34. Richards M, Wadsworth MEJ. Long term effects of early adversity on cognitive function.
433   *Arch Dis Child* 2004; **89**:922-927.

434 35. Geoffroy M, Pereira SP, Li L, Power C. Child neglect and maltreatment and childhood-to-
435   adulthood cognition and mental health in a prospective birth cohort. *Journal of the American*
436   *academy of child & adolescent psychiatry* 2016; **55**(1).

437 36. Fantuzzo JW, LeBoeuf WA, Rouse HL. An investigation of the reations between school
438   concentrations of student risk factors and student educational well-being. *Educational*
439   *researcher* 2013; **43**(1):25-36.

440 37. Ragnarsdottir LD, Kistjansson AL, Thorisdottir IE, Allegrante JP, Vladimarsdottir H,
441   Gestsdottir S et al. Cumulative risk over the early life course and its relation to academic
442   achievement in childhood and early adolescence. *Preventative medicine* 2017; **96**:36-41.

443 38. Mills R, Kisely S, Alati R, Strathern L, Najman JM. Cognitive and educational outcomes of
444   maltreated and non-maltreated youth: A birth cohort study. *Aust N Z J Psychiatry* 2019;
445   **53**(3):248-255.

446 39. Almquist YB, Brännström L. Childhood Adversity and Trajectories of Disadvantage Through
447   Adulthood: Findings from the Stockholm Birth Cohort Study. *Soc Indic Res* 2018;
448   **136**(1):225–245.

449 40. Metzler M, Merrick MT, Klevens J, Ports KA, Ford DC. Adverse childhood experiences and
450   life opportunities: Shifting the narrative. *Children and Youth Services Review* 2017; **72**:141-
451   149.

452 41. Kane GA, Wood VA, Barlow J. Parenting programmes: a systematic review and synthesis of
453   qualitative research. *Child: care, health and development* 2007; **33**(6):784-793.

454 42. Barlow J, Coren E. The Effectiveness of Parenting Programs: A Review of Campbell
455   Reviews. *Research on social work practice* 2018; **28**(1).

456 43. Anderson LM, Shinn C, Fullilove MT, Scrimshaw SC, Fielding JE, Normand J et al. The
457   effectiveness of early childhood development programs: A systematic review. *American*
458   *Journal of Preventive Medicine* 2003; **24**(3):32-46.

459 44. Hahn RA, Barnett WS, Knopf JA, Truman BI, Johnson RL, Fielding JE et al. Early
460   Childhood Education to Promote Health Equity: A Community Guide Systematic Review. *J*
461   *Public Health Manag Pract* 2016; 22(5):E1–E8.

462 45. Wiest-Stevenson C, Lee C. Trauma-Informed Schools. *Journal of evidence-informed social*
463   *work* 2016; **13**(5).

464 46. Chafouleas SM, Johnson AH, Overstreet S, Santos NM. Toward a Blueprint for Trauma-
465   Informed Service Delivery in Schools. *School Mental Health* 2016; **8**:144-162.

468

469

470

471

472

473

474

475

476

477

478

479

480

481

482

483

484

485

486
487